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PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 68: GOLDEN NEMATODE

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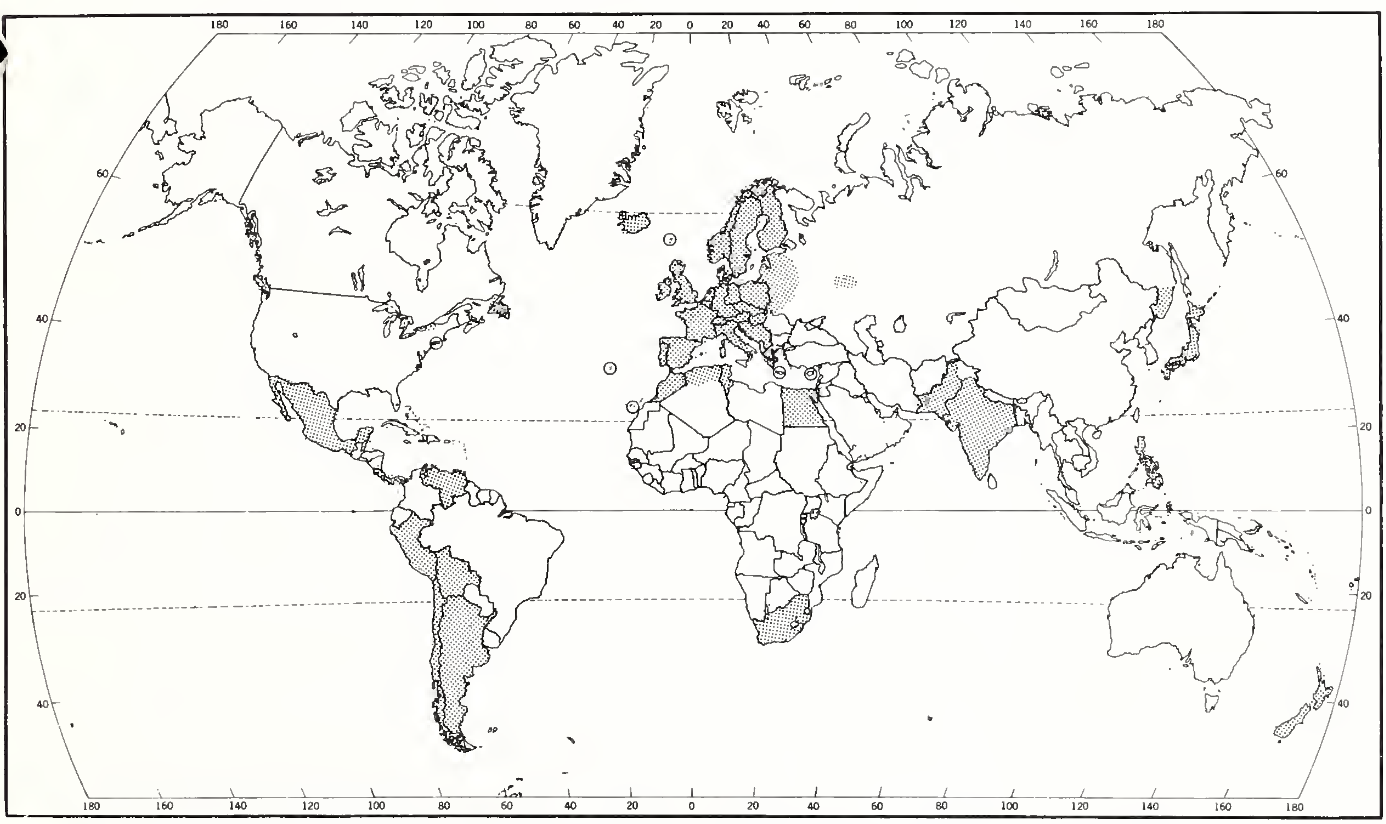
Pest GOLDEN NEMATODE
Globodera rostochiensis (Wollenweber) Behrens

Synonym *Heterodera rostochiensis* Wollenweber

Order: Family Tylenchida: Heteroderidae

Economic Importance Yield losses depend primarily upon the nematode population density modified by potato cultivar, soil type, environmental influences, and agronomic practices. Reduced yields can occur at nematode population levels that produce no obvious above ground symptoms (Brown 1961). Field trials testing differences in tolerance of potato cultivars to *G. rostochiensis* resulted in yield losses of 19-90 percent (Trudgill and Cotes 1983). Losses were as high as 70 percent in the field on Long Island where *G. rostochiensis* was first discovered in the United States (Spears 1968).



Globodera rostochiensis distribution map (Prepared by Non-Regional Administrative Operations Office and Biological Assessment Support Staff, PPQ, APHIS, USDA).

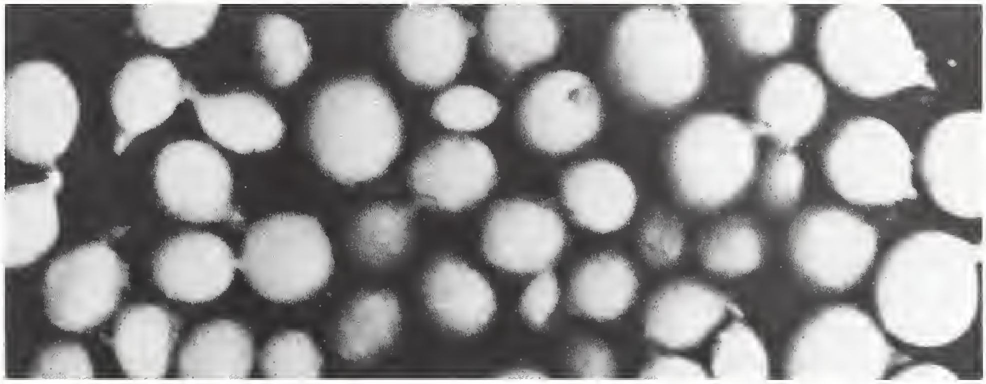
General Distribution	Algeria, Argentina, Austria, Belgium, Bolivia, Canada (Newfoundland, Vancouver Island), Channel Islands (Guernsey, Jersey), Chile, Costa Rica, Cyprus, Czechoslovakia, Denmark, East Germany, Egypt, Faeroe Islands, Finland, France, Greece (includes Crete), Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Lebanon, Luxembourg, Mexico, Morocco, Netherlands, New Zealand, Norway, Pakistan, Panama, Peru, Philippine Islands, Poland, Portugal (includes Azores), South Africa, Soviet Union, Spain (includes Canary Islands), Sweden, Switzerland, Tunisia, United Kingdom, United States (New York), Venezuela, West Germany, and Yugoslavia.
Hosts	*Lycopersicon esculentum* (tomato), *Solanum melongena* (eggplant), and *S. tuberosum* (potato) are the commonly cultivated plant hosts. Other species of the genus *Solanum*, some of which are cultivated in South America, are also hosts.
Characters	Data from Golden and Ellington, 1972 (measurements in micrometers)

FEMALES (n = 50) - Body length (including neck) = 520 (420-640), width = 340 (270-430), L/W ratio = 1.5 (1.2-2.0), stylet length = 23 (22-24), stylet base to outlet of dorsal esophageal gland = 6.2 (5.8-7.0), excretory pore from anterior end = 131 (105-175), vulval length = 12 (7-14) and width = 7 (5-11), vulval slit length = 9 (6-11), anus from nearest edge of vulva = 47 (39-80).

Body subspherical with projecting neck, white (Fig. 1) then passing through golden yellow phase as cyst is formed. Cuticle reticulate, punctate just below surface. Head with one or two annules. Cephalic framework weakly developed. Stylet knobs rounded, sloped posteriorly. Median bulb large, nearly spherical, with well developed valve. Esophageal glands in broad lobe, often obscure, frequently displaced forward by developing paired ovaries. Excretory pore near base of neck (Fig. 2). Vulva not set off from body, opposite neck, in slight almost circular depression. Anus smaller than vulva, at right angle to axis of vulval slit.

CYSTS (n = 50) - Length (including neck) = 680 (450-990), width = 540 (250-810), L/W ratio = 1.27 (1.0-1.8), diameter or longest axis of fenestra (A) = 15 (8-20), distance from anus to nearest edge of fenestra (B) = 68 (29-116), B/A ratio = 4.5 (2.0-7.0).

(Figs. 1-2)



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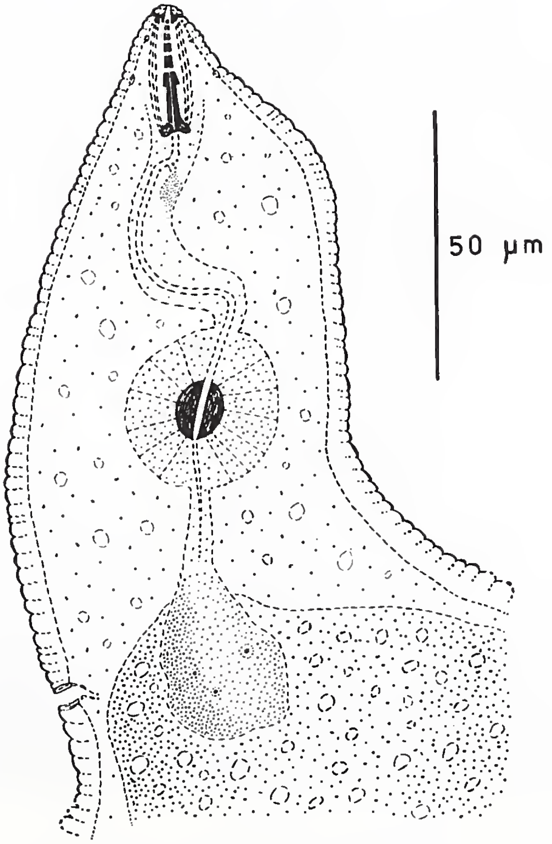

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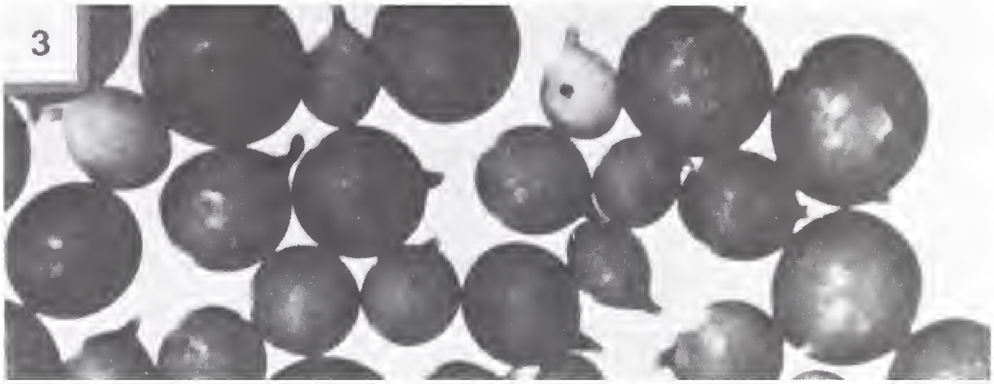
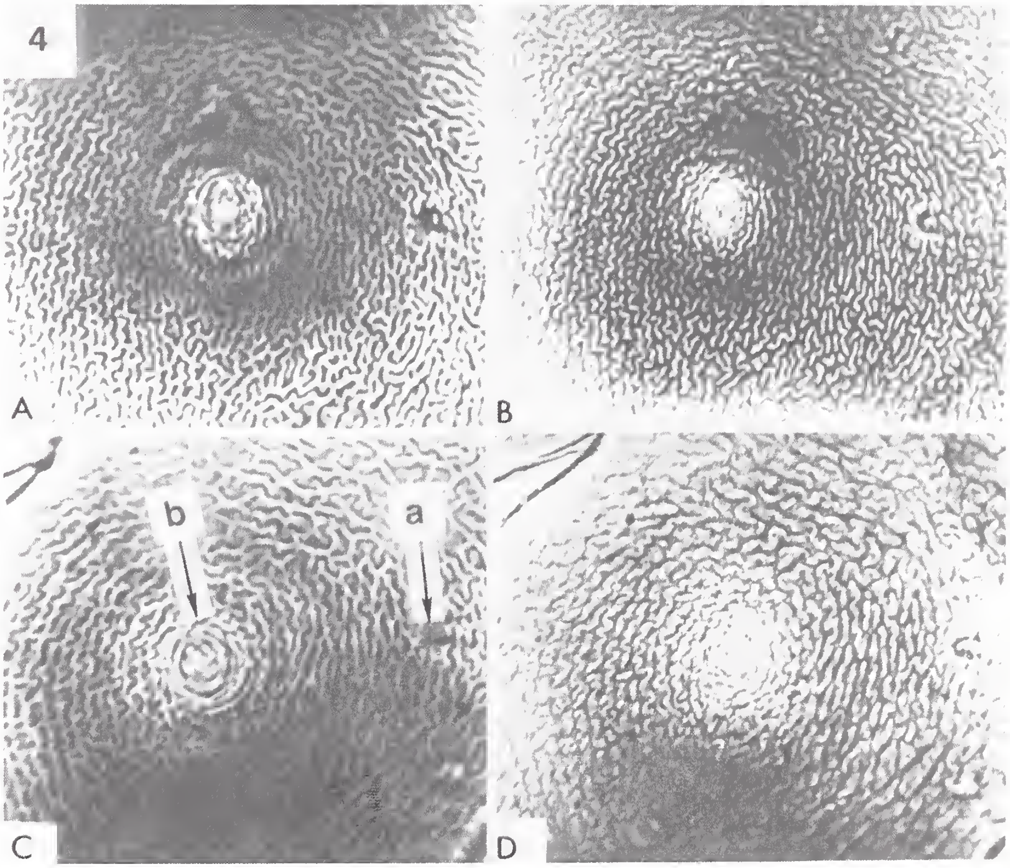
Globodera rostochiensis females. 1. Entire. 2. Anterior portion (From Golden and Ellington 1972).

(Figs. 3-4)





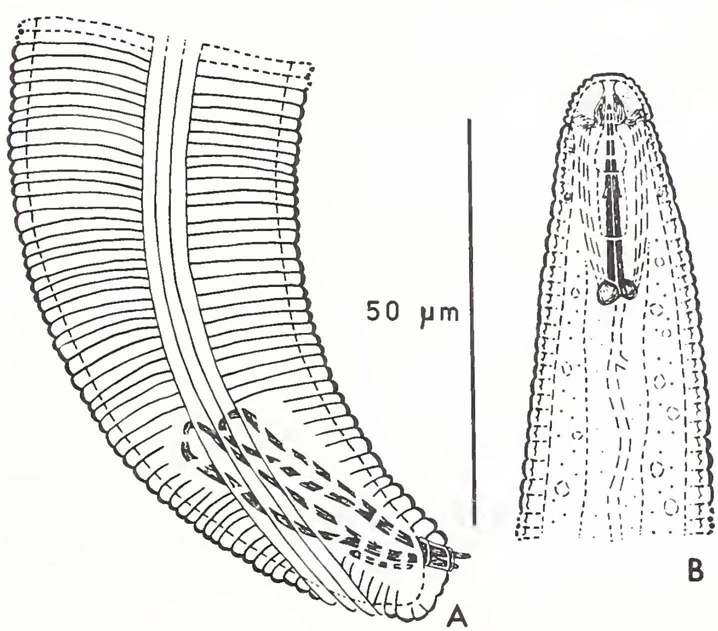
Globodera rostochiensis cysts. 3. Entire. 4. Fenestral-anal area: A. Outer surface, B. Deeper focus of same; C. Outer surface of second cyst: a - anus, b - fenestra, D. Deeper focus of same (Note differences in pattern between the two cysts and at different focus.) (From Golden and Ellington 1972).

Cyst brown, subspherical to spherical, with projecting neck (Fig. 3). Vulval region forming single circular fenestra (Fig. 4) in older cysts, abullate. Anus small, may be at apex of V-shaped structure (Fig. 4A-D). Cyst wall pattern (Fig. 4) similar to that of female but often more prominent. Usually punctate.

MALES (n = 50) - Body length = 1080 (890-1270), width = 39 (31-46), a = 27 (22-36), b = 5.9 (4.9-7.3), c = 267 (161-664), stylet length = 26 (25-27), stylet base to outlet of dorsal esophageal gland = 6.4 (5.3-7.0), head to center of median bulb = 99 (85-112), spicule length = 35 (32-39), gubernaculum length = 12 (10-14), tail length = 4.4 (1.7-6.7), lateral field width = 7.0 (6.7-8.4).

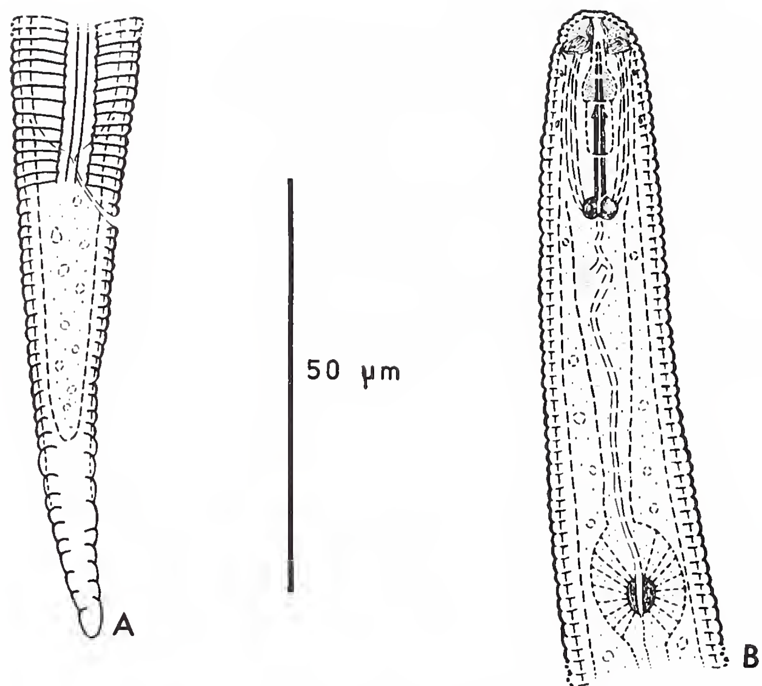
Body vermiform, cuticular annulation prominent. Lateral field with 4 incisures (Fig. 5A). Head slightly offset, hemispherical, 6-7 annules (Fig. 5B). Cephalic framework heavily sclerotized. Stylet strong with prominent knobs slightly backward sloping. Median bulb ellipsoidal with prominent valve. Esophageal glands narrow, ventral, terminating near excretory pore. Hemizonid 2 annules long, 2-3 annules anterior to excretory pore. Testis single, spicules with tips rounded, unnotched. Tail short (Fig. 5A), length and shape variable. Phasmids not reported.

(Fig. 5)



Globodera rostochiensis male. A. Posterior. B. Anterior (From Golden and Ellington 1972).

(Fig. 6)



<u>Globodera</u> <u>rostochiensis</u> second-stage juvenile. A. Posterior. B. Anterior (From Golden and Ellington 1972).

SECOND-STAGE JUVENILES (n = 50) - Body length = 430 (370-470), width = 23 (19-26), a = 19 (16-23), b = 2.3 (2.2-2.5), c = 8 (7-9), stylet length = 22 (21-23), stylet base to outlet of dorsal esophageal gland = 5.5 (5.0-6.7), anterior end to center of median bulb = 68 (64-76), tail length = 51 (44-57), hyaline tail terminal = 24 (18-30), caudal ratio A = 3.4 (2.8-4.4), caudal ratio B = 10.8 (5.5-17.0).

Body vermiform, cuticular annulation prominent. Lateral field with 4 incisures (Fig. 6A). Head slightly offset, rounded, bearing 4-6 annules. Cephalic framework heavily sclerotized. Stylet well developed, knobs rounded, slightly backward sloping (Fig. 6B). Median bulb ellipsoidal with prominent valve. Esophageal glands extend ventrally for about 35 percent of body length. Hemizonid 1 annule anterior to excretory pore. Four-celled genital primordium about 60 percent of body length. Tail tapered to finely rounded terminus (Fig. 6A). Phasmids difficult to see, about half way on tail.

EGGS (n = 50) - Length = 105 (95-115), width = 45 (42-48), L/W ratio = 2.3 (2.0-2.6).

Egg shell hyaline. Second-stage juveniles folded four times in egg.

G. rostochiensis is similar to G. pallida from which it differs by the shorter length of the juvenile stylet (22 versus 24 um in G. pallida), the size and shape of the juvenile stylet knobs, and a larger B/A ratio in the cyst (average 3.6-4.5 versus average 2.1-2.5 in G. pallida).

Characteristic Damage

Above ground symptoms result from a high nematode population. Symptoms, often indistinguishable from water or nutrient deficiency, first appear as localized areas of poor growth. Plants are smaller than normal with yellow leaves and may wilt, especially around midday. The white or golden females that have broken through the root surface may be seen if the roots are carefully lifted and examined at flowering time. As the nematode population increases in succeeding years, the patchy areas expand and may elongate due to spread of the nematode by cultivation or runoff water. Additional patches may appear. Yield declines because fewer and smaller tubers are formed. Up to 20 years may lapse between pest introduction to symptom development above ground and yield reduction.

Detection Notes

The Plant Quarantine Act of 1912 contained a prohibitory provision to the fungal pathogen of potato wart (Synchytrium endobioticum (Schilbersky) Percival). This provision helped prevent widespread introductions of G. rostochiensis into the United States because potato wart and golden nematode spread by similar methods.

Besides being carried with its hosts, G. rostochiensis has been found in soil, even minute amounts, from sod and on many other different plant and nonplant products entering the United States. Some of these plants and bulbs for propagation are species of Acacia, Adiantum, Allium, Amaryllis, Arabis, Asparagus, Begonia, Buxus, Cactaceae, Calluna, Cedrus, Chrysanthemum, Cineraria, Coleus, Convallaria, Crocus, Cyclamen, Dahlia, Delphinium, Dianthus, Erica, Euonymus, Ficus, Fragaria, Fuchsia, Gaillardia, Galanthus, Gladiolus, Glechoma, Hedera, Helleborus, Heuchera, Hibiscus, Hyacinthus, Hydrangea, Ilex, Iris, Juniperus, Lavandula, Ligustrum, Lilium, Lupinus, Mentha, Myrtus, Narcissus, Nepeta, Oxalis, Paeonia, Pelargonium, Picea, Pinus, Polianthes, Primula, Rhododendron, Ribes, Rosa, Rosmarinus, Rubus, Saintpaulia, Saxifraga, Scabiosa, Scilla, Sedum, Sinningia, Soleirolia, Syringa, Thymus, Trifolium, Tritonia, Tulipa, Viola, and Vitis.

Other carriers of cysts have been garlic, horseradish, and onion cargoes for consumption, hay packing around dishes, packing for old toys, new and used autos and trucks, used bagging, old

cordage, ballast, boots and shoes, military tanks and equipment, crates, vial of soil in purse, and farm tractors. Many have been made intercepted from root crops in ship's stores.

<u>On imports</u>, collect soil clinging to plant material by cutting off dirty roots or the base of bulbs. When soil is not apparent, tap or knock surface dust onto clean paper. Inspection stations can wash plant material over screens without cutting. Be alert for soil with nonplant cargoes.

<u>In the field</u> the most reliable method for detection is the collection of soil samples and processing by a wet screening method. Agricultural Handbook No. 353, The Golden Nematode Handbook, explains the survey and laboratory procedures in detail. Small populations are difficult to detect.

For identification, a minimum of 10 cysts with juveniles is desirable. Interceptions at ports of entry generally contain smaller numbers of cysts. Males, females, and the name of the host will help in identifying field infestations.

Biology

Probably few juveniles survive the winter free in the soil. Most, if not all, infective second-stage juveniles overwinter coiled within their egg shells inside the dead female body, the cyst. Juveniles are resistant to drying while in the egg protected by the cyst. In spring, secretions from host roots stimulate juveniles to hatch. About 60-80 percent of viable juveniles hatch (Jones 1970). Hatch in water is light. Juveniles are often inactive below 13° C, but at 15-16° C they may invade host roots in mass (Chitwood and Buhrer 1946). Juveniles escape from the cyst through the broken neck opening and the disintegrating cuticle around the short vulval slit (fenestra). They penetrate roots just behind the tip and begin feeding on a group of pericycle, cortex, or endodermal cells, which are stimulated to form a syncytium by secretions from the juveniles. The feeding juveniles enlarge except for the neck region, lose the ability to move, and feed upon the same syncytium throughout their lives. After undergoing three molts, juveniles reach the adult stage. During this time, the posterior end of their enlarging bodies has broken through the surface of the root. Adult males, being vermiform and motile, emerge from the roots. They are attracted to the females, which are attached to the roots, and mate with them. Both sexes mate several times (Green et al. 1970). Males live about 10 days in the soil (Evans and Stone 1977). Impregnated females continue to feed and become filled with eggs, which develop to second-stage juveniles within the female. A life cycle is completed in 38-48 days at 15-21° C (Chitwood and Buhrer 1946). Juveniles do not develop at 30° C (Ferris 1956). One generation is generally produced each year.

When females die, their cuticles toughen and turn brown after going through a light yellow or golden phase. Each cyst may contain 200-500 embryonated eggs. At harvest when the roots are disturbed, the cysts are detached from the root surfaces and become free in the soil.

Control

Rotation with a nonhost crop lowers the number of nematodes. In cool areas, viable juveniles decline annually about 18 percent in soil without a host, yet juveniles are still viable in soil after 30 years (Grainger 1964). In warmer climates, decline of viable juveniles without a host may be so high, 50-80 percent (Stone 1973), that relatively short rotations would reduce populations to very small levels. Rotation time varies with the initial nematode density. Other factors such as soil type and soil temperature also affect the rate of decline of the nematode population. It may take 4-7 years before potatoes can be grown without being damaged.

Commercial cultivars of potatoes resistant to *G. rostochiensis* can reduce nematode populations by 80-95 percent each year (Brodie 1976). Limited nematode reproduction occurs however. There are five races of *G. rostochiensis*, but only one, Ro 1, occurs in the United States. Resistant potato cultivars available in the United States resist this one race but not the other four races. Foreign potato cultivars resistant to some of the other races, are not adapted to the New York climate.

Natural Enemies

Several species of fungi attack *G. rostochiensis*, but none so far have proven effective control agents.

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